

2014-1510

United States Court Of Appeals for the Federal Circuit

THE BOARD OF TRUSTEES OF THE UNIVERSITY OF ILLINOIS,
Appellant,

v.

MICRON TECHNOLOGY, INC.,
Appellee,

APPEAL FROM THE UNITED STATES PATENT AND TRADEMARK OFFICE BEFORE THE
PATENT TRIAL AND APPEAL BOARD IN CASE NO. IPR2013-00006

ADMINISTRATIVE PATENT JUDGES SALLY GARDNER LANE, BRYAN F. MOORE, AND
MICHAEL J. FITZPATRICK

MICRON'S OPPOSITION BRIEF

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October 14, 2014

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CERTIFICATE OF INTEREST

Counsel for Micron Technology, Inc., certifies the following:

1. The full name of every party or amicus represented by me is: Micron Technology, Inc.
2. The name of the real party in interest (if the party named in the caption is not the real party in interest) represented by me is: N/A.
3. All parent corporations and any publicly held companies that own 10 percent or more of the stock of the party or amicus curiae represented by me are: N/A.
4. The names of all law firms and the partners or associates that appeared for the party or amicus now represented by me in the trial court or agency or are expected to appear in this court are:

Fish & Richardson P.C.: Ruffin B. Cordell, Timothy W. Riffe and Adam R. Shartzner.

Dated: October 14, 2014

/s/ Adam R. Shartzner
Adam R. Shartzner

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STATEMENT OF RELATED CASES

The University's statement of related cases is accurate to Micron's understanding.

STATEMENT OF JURISDICTION

The University's statement of jurisdiction is accurate.

STATEMENT OF THE ISSUES

The University's statement of the issues is inaccurate for several reasons. First, the Board found that claim 13 of the '204 patent is rendered obvious over the following four grounds:

- i) Lisenker¹ (alone);
- ii) Lisenker in view of Gise²;
- iii) Lisenker in view of Gise and Ito³; and
- iv) Deal⁴ in view of Lisenker and Ito.

Thus, the issues are those of obviousness and not anticipation, where the University must prevail over all four obviousness determinations to otherwise disturb the Board's judgment. The University also fails to identify the proper standard of review. The issues when stated accurately are:

¹ A1648-66 (WO 94/19829 to Lisenker *et al.* (Sep. 1, 1994)).

² A1708-18 (Peter Gise & Richard Blanchard, Semiconductor and Integrated Circuit Fabrication Techniques, 129-131 (Reston Publishing Co., Inc. 1979)).

³ A1673-A1697 (U.S. Patent No. 4,980,307 to Ito *et al.* (Dec. 25, 1990)).

⁴ A1698-A1707 (U.S. Patent No. 4,027,380 to Deal *et al.* (June 7, 1977)).

1. Claim 13 of U.S. Patent No. 6,888,204 (“the ’204 patent”) claims a semiconductor device having deuterium at the interface between a semiconductive silicon layer and a gate insulating layer to provide a practical lifetime at least about ten times that provided by a corresponding passivation with hydrogen. Lisenker discloses a semiconductor device having deuterium at the interface between a semiconductive silicon layer and a gate insulating layer (hereinafter, “the interface”) in such an amount that the ratio of deuterium containing bonds to hydrogen containing bonds is 99 to 1. Thus, Lisenker discloses i) the identical mechanisms (pre- and/or post-metal passivation in deuterium) and ii) the identical structure (deuterium at the interface) disclosed by the ’204 patent for obtaining the “ten times” lifetime improvement.

Lisenker also recognizes that replacing deuterium with hydrogen will result in devices having “improved stability, quality, and reliability.” Thus, the first issue on appeal is whether substantial evidence supports the Board’s finding that the element from claim 13 of the ’204 patent: “to provide to said transistor a practical lifetime at least about ten times that provided by a corresponding passivation with hydrogen” is disclosed or rendered obvious by Lisenker either alone or in view of Gise or further in view of Ito.⁵

⁵ The combination of Lisenker in view of Gise and Ito stands or falls with the Court’s determination as to the combination of Lisenker in view of Gise alone. That is because the University does not appeal any issue germane to either the teachings or

2. Deal discloses a field effect transistor with an interface between a semiconductive silicon layer and a gate oxide layer and performing a post-metal passivation step in hydrogen. Lisenker discloses substituting deuterium for hydrogen throughout the VLSI procedure, which includes a post-metal passivation step. Thus, the second issue on appeal is whether substantial evidence supports the Board's finding that the limitation from claim 13 of the '204 patent: "said post-fabrication passivation being conducted sufficiently to provide to said transistor a practical lifetime at least about ten times that provided by a corresponding passivation with hydrogen," is disclosed or rendered obvious by Deal in view of Lisenker and Ito.
3. The Board construed claim 13 of the '204 patent as a product-by-process claim such that the "said post-fabrication passivation being conducted sufficiently to provide to said transistor a practical lifetime at least about ten times that provided by a corresponding passivation with hydrogen" limitation of claim 13 need not be considered for patentability. This finding renders Issues 1 and 2 moot. Therefore, the third issue on appeal is whether the University can even challenge whether the prior art inherently discloses a ten-times lifetime

combinability of Ito. Ito is combined for its express teaching of a gate insulating layer thickness dimension.

improvement in view of the Board's determination that the aforementioned limitation need not be considered for patentability.⁶

⁶ The University failed to challenge the Board's claim construction decision in its Blue brief and has, therefore, waived this issue.

STATEMENT OF THE CASE

This is an appeal from an *inter partes* review proceeding as to the University's '204 patent, which relates to annealing (also known as passivating) semiconductor devices with deuterium instead of hydrogen. This appeal is about whether the recitation of a quantified (10-fold) semiconductor lifetime improvement in product-by-process claim 13 of the '204 patent is a patentable distinction over the prior art. The prior art indisputably discloses the identical structure and process that the '204 patent discloses to achieve the claimed 10-fold semiconductor lifetime improvement.

Micron sought *inter partes* review of the '204 patent on October 2, 2012, along with two other patents that are relatives of the '204 patent. The Board's final written decisions in the *inter partes* reviews of those related patents are also subject to appeal in the consolidated case. The Board instituted *inter partes* review of all claims of the '204 patent (claims 1-18) on March 13, 2013 and issued a final written decision cancelling all claims of the '204 patent on March 10, 2014. The only claim the University appeals is claim 13. Any arguments as to the patentability of the remaining claims are thus waived.

All claims of the '204 patent are directed to a semiconductor device and recite i) the existence of deuterium at the interface between a conductive silicon layer and a gate insulating layer and ii) an improvement in resilience or lifetime. *See, e.g.*, '204 patent, claims 1, 6, 10, 14, and 15. The Board found all claims of the '204 patent unpatentable as obvious over Lisenker either alone and/or in combination with other

prior art. On appeal, however, the University ties all of its arguments to claim 13 of the '204 patent, which unlike the other claims, actually quantifies the lifetime improvement as "ten times." Thus, the parties do not dispute that Lisenker discloses the existence of deuterium at the interface or that Lisenker discloses an improvement in resilience/lifetime. The primary issue on appeal (among others) is narrow. It is simply whether Lisenker alone or in combination with other art discloses or renders obvious this 10-fold lifetime improvement.

While the University appeals only claim 13, the University did not separately argue for the patentability of claim 13 to the Board. The University made a common argument for patentability to the Board that ran across all claims of the '204 patent. The University's prior arguments to the Board, below, can be summed up as follows:

- i) while Lisenker discloses passivating semiconductor devices in deuterium, it does not disclose post-metal passivation;
- ii) post-metal passivation in deuterium results in deuterium at the interface, which in turn results in a 10-fold lifetime improvement;
- iii) on the other hand, pre-metal passivation does not result in deuterium at the interface because subsequent thermal processing causes the deuterium to migrate away from the interface; and
- iv) because Lisenker only discloses pre-metal passivation, it cannot disclose (or enable) the existence of deuterium at the interface or the attendant 10-fold

lifetime improvement. (*See* University’s Patent Owner Response, A1822-23.)⁷

The Board disagreed. The University did not seek rehearing. This appeal followed.

Intrinsic to the University’s argument is the logical relationship between post-metal passivation, deuterium at the interface, and the 10-fold semiconductor lifetime improvement. According to that logic, a post-metal passivation step during the semiconductor manufacturing process (sometimes referred to as the VLSI process) is sufficient to achieve deuterium retained at the interface between a conductive silicon layer and a gate insulating layer. That retained deuterium is sufficient to achieve the 10-fold lifetime improvement. Thus, according to the University, a post-metal passivation step is sufficient to achieve the 10-fold lifetime improvement. What is more, *the University explicitly stated that the 10-fold lifetime improvement “is [] implied by the claimed post-fabrication process step.”* (A1833.) The University’s entire argument, therefore, was premised on Lisenker’s failure to disclose post-metal passivation—an argument which the Board rejected. Indeed, the Board found that Lisenker teaches a semiconductor manufacturing process that includes a post-metal deuterium passivation step. (A35–37.) Because Lisenker teaches this step, the Board found that it inherently teaches an increased resilience to hot electron effects, which results in increased semiconductor resilience. (A37–38.)

⁷ As explained below, the University also made this argument during the original prosecution of the ’204 patent.

On appeal, the University switches its story. Now, it concedes that Lisenker discloses post-metal passivation in deuterium and the existence of deuterium at the interface. Yet it challenges the Board's finding that Lisenker discloses the 10-fold lifetime improvement. Thus, it attempts to sever the previously admitted relationship between post-metal passivation, deuterium at the interface, and the 10-fold lifetime improvement. This relationship, however, is supported by the disclosure of the '204 patent, the University's arguments made during original prosecution and the *inter partes* review below, and the evidentiary record such that the Board's conclusion is supported by substantial evidence.

COUNTERSTATEMENT OF FACTS

Because the University's selective recitation of facts omits key evidence and testimony that are pertinent to the appeal issues, Micron sets forth the following counterstatement of facts.

I. The '204 Patent

The '204 patent "relates to methods for treating semiconductor devices or components thereof in order to reduce the degradation of semiconductor device characteristics over time." (A1066 – '204 patent, 1:22–25.) According to the '204 patent, this is accomplished by treating a semiconductor device by passivating (*i.e.*, annealing) the device with deuterium instead of hydrogen. (A1066 at 2:36–39.) In the words of the '204 patent:

[T]reatment with deuterium provides a reduction in the depassivation or "aging" of semiconductor devices due to hot carrier effects. Such aging is evidenced, for example, by substantial degradations of threshold voltage, transconductance, or other device characteristics. In accordance with the present invention, semiconductor devices are fabricated using deuterium to condition the devices and stably reduce the extent of these degradations.

(A1067 at 3:40–48.)

The '204 patent further explains that the passivation step can occur during or after completion of fabrication. (A1067 at 4:45–48 ("In accordance with the invention, the semiconductor device will be treated with deuterium during or after completion of fabrication so as to condition the device to improve its operating characteristics.")) The '204 patent also discloses that the substitution of deuterium

for hydrogen will result in a lifetime improvement by a factor of ten to fifty. *Id.*, (A1064–65, Figs. 2–3; A1068 at 5:60–65 (“[D]ramatic decreases in the degradation of threshold voltage and transconductance are observed when deuterium is used to passivate the devices, as compared to hydrogen passivation (see FIGS. 2 and 3, respectively). These decreases represent practical lifetime improvements by factors of about ten to fifty”); A1069 at 7:47–49 (“[T]ransistors sintered in deuterium typically exhibit lifetimes 10 times longer than those sintered in hydrogen.”).) The Board noted this disclosure and determined, as a factual matter, that the experimental data in the ’204 patent specification links lifetime extension (including the ten to fifty times semiconductor lifetime improvement noted in Figures 2–3) to ***deuterium passivation in general***. (A28–29.) According to the Board, the experimental data does not link semiconductor lifetime extension to just a post-metal passivation step, as opposed to a pre-metal passivation step. *Id.*

II. The ’204 Patent Prosecution

During prosecution of the ’204 patent, the University relied upon a declaration of its expert, Dr. Wallace, to gain allowance.⁸ In that declaration, Dr. Wallace argued that Lisenker’s key deficiency was its failure to disclose post-metallization annealing. In Dr. Wallace’s view, the post-metal deuterium anneal of the ’204 patent produced a

⁸ Dr. Wallace was the University’s expert during both the prosecution and the later *inter partes* review.

10-fold semiconductor device lifetime improvement that was unanticipated by the device community, whereas pre-metallization annealing does not.

The Examiner states in the Office Action “Applicants have not shown that annealing post-metallization in deuterium is critical or has unexpected results relative to pre-metal annealing in deuterium (*i.e.*, Lisenker).” I must respectfully disagree.

The data presented in the Lyding and Hess specification (pages 21-23 “ANNEALING RUNS” together with Figs. 2 and 3)), **indicate at least an order of magnitude improvement in device performance** - well beyond that taught or anticipated by Lisenker.

(A1935 at ¶ 12.) Thus, the University’s prosecution expert (the same expert it used during the *inter partes* review) clearly tied an “order of magnitude improvement in device [lifetime] performance” (at least 10x) with a post-metallization anneal in deuterium semiconductor device fabrication step. *Id.*

Dr. Wallace also testified that post-metallization annealing is critical because it is the only process that results in the retention of deuterium at the interface.

Taken together, these studies demonstrate that the *retention* of deuterium at the interface necessarily requires the deuterium annealing of the device to be done at a point in the process which precludes the possibility of subsequent migration of deuterium from the gate insulator/semiconductor interface. As such, the recognition of *post-fabrication anneals* in a deuterium ambient uniquely fulfills this requirement.

(A1937 (emphasis in original).)

Dr. Wallace also testified that the 10-fold lifetime improvement corresponded to the retention of deuterium at the interface, resulting from the device’s annealing history (*e.g.*, a post-fabrication anneal in deuterium).

There have been studies, performed after the original reports by Lyding and coworkers, which have demonstrated that the *retention* of deuterium, and the corresponding *orders of magnitude improvement* in device reliability, depends critically upon the annealing history of the device.

(A1936 (emphasis in original).)

Dr. Wallace admitted, however, that a step of “post metal hydrogen annealing had been in widespread use in the semiconductor industry for many years.” (A1938 at ¶ 15 (citing S. Wolf, “Silicon Processing for the VLSI Era” (Lattice, Sunset Beach, CA, 1995), Vol. 3, p425, 428).)

III. The Prior Art

A. Lisenker

Lisenker discloses “a method for producing semiconductor devices in which hydrogen-containing bonds in silicon dioxide are replaced with deuterium containing bonds. Specifically Si-H bonds are replaced with Si-D bonds and Si-OH bonds are replaced with Si-OD bonds.” (A1654–55 at 5:36–6:3.) Lisenker states that this method can be accomplished by substituting deuterium for hydrogen at any stage of the VLSI process.⁹ (A1653 at 4:20–34; A1654 at 5:6–9; A1657 at 8:29–35.)

Lisenker, like the ’204 patent, discloses that the substitution of deuterium for hydrogen results in deuterium at the interface. For example, Lisenker discloses:

⁹ It is undisputed that a post-metal annealing step is part of the VLSI process. (A35–36; *see also* A12; A65–66 (related findings as to Lisenker’s discussion of the VLSI process in the Final Written Decisions for the *inter partes* reviews of the other two related University patents).)

The regions where the deuterated bonds provide the greatest benefit in terms of device performance is at the interface of silicon-silicon dioxide layers. Thus, the semiconductor devices of this invention will have at this interface a ratio of Si-OD plus Si-D bonds to Si-OH plus Si-H bonds that is substantially greater than ratio of naturally occurring deuterium to hydrogen.

(A1659 at 10:29–35; *see also* A1661 at 12:3–9, 15–17 (Lisenker’s claim 3: “The semiconductor device of claim 2 wherein the ratio of Si-OD plus Si-D bonds to Si-OH plus Si-H bonds is greater than about 99:1.”).)

Lisenker, like the ’204 patent, discloses that the presence of deuterium (rather than hydrogen) at the interface results in improved device lifetime.

The stability of oxide layers is improved in the present invention because the bond energy of the Si-H and Si-OH bonds is increased by replacing the hydrogen atoms with deuterium atoms. The Si-D and Si-OD bonds thus formed provide completed silicon dangling bonds that are less likely to break when exposed to electrical stresses. Therefore, the deuterium containing devices of the present invention have improved stability, quality, and reliability.

(A1653–54 at 4:35–5:5.)

Moreover, Micron’s expert, Dr. Reed, testified that another prior art reference, Mikawa¹⁰, evidenced tests to compare the effects of substituting deuterium for hydrogen and recognized a lifetime improvement consistent with the 10-fold improvement claimed by the ’204 patent.

¹⁰ (A1667–72 (R.E. Mikawa & P.M. Lenahan, Electron Spin Resonance Study of Interface States Induced by Electron Injection in Metal-Oxide Semiconductor Devices, 59 (6) J. Appl. Phys. 2054 (Mar. 15, 1986)).)

Mikawa also considered the large isotope effect of deuterium and examined its effects on the Si/SiO₂ interface. Mikawa examined the structural damage at the Si/SiO₂ interface caused by the injection of hot electrons in MOS devices. Mikawa observed that such electron injection generates interface states at the Si/SiO₂ interface. In one of the tests, Mikawa annealed samples in deuterium at 450°C to compare hydrogen passivation with deuterium passivation. Mikawa observed less electron trapping at the Si/SiO₂ interface of the samples annealed in deuterium than the otherwise identical samples that were annealed in hydrogen. Mikawa attributed such results to the well-known large isotope effect of deuterium. ***Mikawa states that “room temperature reaction rates involving hydrogen bond breaking events are frequently reduced by an order of magnitude when hydrogen is replaced by its heavier stable isotope, deuterium.” Mikawa’s observations are consistent with the 10X improvement in device lifetime characteristic claimed by the ’204 patent.***

(A1014 at ¶¶ 32–33 (internal citations omitted) (emphasis added); *see also* A1969 at ¶ 10; A1670 - Mikawa.)¹¹ Dr. Reed testified that a person of ordinary skill in the art at the time of invention of the ’204 patent would have interpreted Lisenker in view of Mikawa’s teaching and would have understood that an order of magnitude (at least 10x) improvement in semiconductor lifetime would occur by employing Lisenker’s teachings.

Dr. Reed also testified that Lisenker discloses representative values of molecular bond energies of hydrogen- and deuterium-containing bonds and that from these values it is possible for one of skill in the art to estimate relative rates of bond-breaking reactions, which correlate to the lifetime of the device. Given these values,

¹¹ Micron’s expert also explained that the “bond breaking” referred to by Mikawa is the mechanism that causes device degradation and, therefore, a reduction in bond breaking events directly corresponds to a lifetime improvement. (A1004–06 at ¶¶ 12–14.)

Dr. Reed derived the corresponding difference in rates at room temperature and determined the difference for the Si-H and Si-D bonds is approximately 3.9 and the difference of the O-H and O-D bonds is approximately 35. (A1009–13 at ¶¶ 20–29.) Dr. Reed concluded that these results (correlated to an estimated lifetime improvement between 3.9x and up to 35x) were also consistent with the disclosure of the '204 patent. (A1012–13 at ¶ 29.)

B. Gise

Gise discloses a semiconductor device with an interface between a semiconductive silicon layer and a gate oxide layer. (A1717–18, Gise at 130–31.) Gise further discloses a post-metal passivation step in hydrogen. *Id.*

C. Deal

Deal discloses a field effect transistor with an interface between a semiconductive silicon layer and a gate oxide layer. (A1706, Deal at 9:54–56.) Deal further discloses a post-metal passivation step in hydrogen. (A1706 at 9:33–53.)

IV. The Board's Findings

A. Product-By-Process Claim Format

The Board determined that claim 13 must be given product-by-process treatment, such that claim 13 requires deuterium at the interface, “but not as a result of any particular process.” (A29.) At oral argument, the University conceded that the Board’s claim construction requiring product-by-process treatment was sound. (A2121 at 27:2–9.) Because the process steps of product-by-process claims are not

considered for purposes of patentability—the Board found that a 10-fold semiconductor lifetime improvement need not be considered for purposes of patentability. (A27–29; *see also* A1783–84, Notice of Institution at 12–13.)

B. The Lisenker Prior Art Reference

The Board found, as a factual matter, that Lisenker discloses retention of deuterium at the interface of the semiconductive silicon layer and a gate oxide layer. (A37). The Board also determined that Lisenker expressly and inherently discloses an increased resilience to hot electron effects. (A37–38.) In addition, the Board found that Lisenker “teaches the use of deuterium-as opposed to using hydrogen ‘throughout the VLSI fabrication procedure.’” (A35 (citing A1657, Lisenker at 8:29–30).) The Board thus rejected the University’s argument that Lisenker was limited to a pre-metal passivation. *Id.* It stated that “Lisenker includes numerous additional teachings that undermine the University’s argument that Lisenker’s use of deuterium is limited to pre-metallization passivation.” *Id.*

The Board also found—specifically regarding claim 13—that “Lisenker . . . teaches the subject matter of these claims except for the [gate insulating film] thickness limitation.” (A41.) The Board, nevertheless, credited the testimony of Micron’s expert “that, at the time of filing the ’204 patent, it would have been apparent to one of ordinary skill in the art to reduce the thickness of the gate insulating film of Lisenker to about 55 Angstroms or less, consistent with the general,

decades-long trend of device miniaturization in the semiconductor industry.” *Id.* (quoting A1018–19, Dr. Reed Declaration at ¶ 38).

As to the ground of rejection involving the combination of Lisenker in view of Gise, the Board found that Gise teaches a post-metal anneal in hydrogen. It credited Dr. Reed’s testimony “that ‘it would have been apparent to perform Lisenker’s [deuterium] annealing process after the metallization steps have been performed in light of Gise’s teaching.” (A43 (quoting A1017–18, Reed Declaration at ¶ 36).) The Board, therefore, concluded that “Micron has made a . . . showing that the subject matter of claims 1, 2, 4–7, 9–16, and 18 would have been obvious over Lisenker and Gise.” *Id.*¹²

As to the instituted ground involving the combination of Deal in view of Lisenker and Ito, the Board found that Deal teaches the subject matter of the claims except for the retention of deuterium at the interface. (A46.) Specifically, the Board found that Deal discloses a semiconductor post-metal annealing step in hydrogen, rather than deuterium. (A47.) The Board, nevertheless, determined that “Lisenker suggests to the person of ordinary skill in the art to modify Deal’s post-metal anneal by substituting deuterium for hydrogen.” *Id.* For this reason, the Board concluded at institution that “the subject matter of claims 6-18 would have been obvious over Deal, Lisenker, and Ito.” (A48.)

¹² For the same reasons, the Board found that the subject matter of claims 6-18 would have been obvious over Lisenker, Gise, and Ito. (A44–45.)

INTRODUCTION

The University, saddled with needing to surmount four obviousness findings against claim 13, uses this appeal to switch horses mid-stream. It previously attacked the prior art for an alleged failure to disclose post-metal passivation in deuterium, which according to the University was the key distinguishing feature of its patent. Having lost that issue, it now seeks to sever what it previously admitted as the inherent relationship between post-metal deuterium passivation, retention of deuterium, and a ten-times semiconductor lifetime improvement. The University's new position, however, is contrary to the arguments it and its expert made during both prosecution and the *inter partes* review below.

The '204 patent discloses a method of annealing/passivating a semiconductor device during the manufacturing process in an ambient comprising deuterium. The specification teaches that devices annealed in deuterium will exhibit a ten-to-fifty-times increase in lifetime performance over the same devices annealed in hydrogen. The specification, however, makes no distinction between the use of pre-metal versus post-metal deuterium passivation in achieving the lifetime improvement, such as the 10-times improvement of claim 13. (*See* A1064–65, Figs. 2–3; A1068 at 5:60–65; A1069 at 7:47–49; A1832.)

Passivation of semiconductor devices (including post-fabrication passivation) in hydrogen was a known process in the art well before the University's patent. (A1938 at ¶ 15.) This semiconductor fabrication processing step was understood to achieve

greater device lifetime performance by tying off “dangling bonds” present at interface between the semiconductor and insulator layers. Such dangling bonds contribute to “hot electrons,” which reduce device performance through increased device degradation.

Lisenker—the key prior art reference at issue—described the problems of semiconductor degradation due to these hot electrons and proposed a solution to this long-standing problem. (A1653 at 4:2–7.) Particularly, Lisenker disclosed that semiconductor stability, quality, and reliability could be improved by substitution of deuterium for hydrogen “in many or all of the fabrication steps that would normally employ hydrogen.” (A1654 at 5:1–9.) Thus, Lisenker disclosed substituting deuterium for hydrogen at both pre-metal and post-metal semiconductor fabrication steps. But Lisenker didn’t stop there. He further described a semiconductor device having both SI-OD and Si-D bonds at the interface, wherein the “ratio of Si-OD plus Si-D bonds to Si-OH plus Si-H bonds is greater than about 99:1.” (A1661, claim 3.) Clearly, Lisenker disclosed a semiconductor device structure having an interface that is saturated with deuterium bonds.

The University cannot run from the fact that the prior art discloses at least the same scope as the process and structure disclosed in the ’204 patent specification. Indeed, at every step of the way—both before the Board, and on appeal—it fails to articulate any differentiation between the patent at issue and the prior art. For at least this reason, the claimed features of the ’204 patent are inherent.

And even if not inherent, the University fails to address how the ten-times lifetime element of claim 13 is not obvious. Nor does the University address why that claim element should even be considered for purposes patentability in view of the Board's determination that the claims are subject to product-by-process treatment.

The Court should thus affirm the Board's judgment rendering claim 13 of the '204 patent invalid. That judgment is supported by substantial evidence.

ARGUMENT

V. **The Board Relied on Substantial Evidence to Determine That the 10-Fold Semiconductor Lifetime Improvement is Inherently Disclosed in the Prior Art**

Obviousness is a question of law based on underlying findings of fact. An analysis of obviousness must be based on several factual inquiries: (1) the scope and content of the prior art; (2) the differences between the prior art and the claims at issue; (3) the level of ordinary skill in the art at the time the invention was made; and (4) objective evidence of nonobviousness, if any. *See Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966). The teachings of a prior art reference are underlying factual questions in the obviousness inquiry. *See Para-Ordnance Mfg., Inc. v. SGS Imp. Int’l, Inc.*, 73 F.3d 1085, 1088 (Fed. Cir. 1995).

“Whether a claim limitation is inherent in a prior art reference is a question of fact.” *Telemac Cellular Corp. v. Topp Telecom, Inc.*, 247 F.3d 1316, 1328 (Fed. Cir. 2001). Accordingly, this Court reviews the Board’s factual determinations regarding inherency for substantial evidence. *In re Sullivan*, 498 F.3d 1345, 1350 (Fed. Cir. 2007). Substantial evidence is “such relevant evidence as a reasonable mind might accept as adequate to support a conclusion.” *Consol. Edison Co. v. NLRB*, 305 U.S. 197, 217 (1938). If “the evidence in [the] record will support several reasonable but contradictory conclusions,” this Court “will not find the Board’s decision

unsupported by substantial evidence simply because the Board chose one conclusion over another plausible alternative.” *In re Jolley*, 308 F.3d 1317, 1320 (Fed. Cir. 2002).

A. Substantial Evidence Supports the Board’s Finding That Lisenker Inherently Discloses the 10-Fold Improvement Because Lisenker Teaches the Identical Process and Structure Disclosed by the ’204 Patent

As noted above, the University does not dispute that Lisenker discloses i) passivation in deuterium (both pre- and post-metal) and ii) that such annealing results in deuterium at the interface. *See* Blue Br. at 8 (“Lisenker teaches the use of pre- and post-metallization annealing...”). Thus, patentability (if at all) of claim 13 must be based on its recitation of “. . . to provide to said transistor a practical lifetime at least about ten times that provided by a corresponding passivation with hydrogen . . .”

1. According to the ’204 patent, a 10-times semiconductor lifetime improvement derives from deuterium retained at the interface from deuterium passivation.

Both the ’204 patent and the University agree that the 10-fold semiconductor lifetime improvement is the necessary result of the retention of deuterium at the interface between the semiconductive silicon layer and a gate oxide layer through a post-metal deuterium passivation step. (A1067 at 3:40–48; A1833.) Indeed, neither the ’204 patent nor the University offer any other explanation for how such a lifetime improvement is achieved. (*See* A1064–65, Figs. 2–3; A1068 at 5:60–65; A1069 at 7:47–49; A1832, University’s Patent Owner Response (arguing that “[the ’204 patent] claim language requires improved resistance to hot carrier effects *resulting from*

retention of deuterium at the silicon/insulator interface **resulting from** post-fabrication passivation using deuterium... that improved resistance... results in a functional difference expressed in a lifetime extension of the device of between 10 and 50 times”) (emphasis in original); *see generally*, Blue Br.) Nor does the patent claim or otherwise describe, for example, any specific amount or concentration of deuterium that must be retained at the interface to achieve a lifetime improvement.¹³ The only explanation provided by the patent for the claimed semiconductor lifetime improvement is that it results from retention of deuterium at the interface. (*See* A1064–65, Figs. 2–3; A1068 at 5:60–65; A1069 at 7:47–49.)

The ’204 patent also discloses that the way deuterium is retained at the interface is by way of a passivation step in deuterium. (*See, e.g.*, A1067 at 4:45-53.) Because, according to the ’204 patent, deuterium passivation results in deuterium at the

¹³ During prosecution of the ’204 patent, the University invoked an interference in an attempt to gain claims directed toward a semiconductor device having a specific concentration of deuterium, where that concentration was claimed to “substantially reduc[e] said degradation associated with hot carrier stress.” (A1308, claim 66.) In remarks to the Examiner, the University specifically stated that the claimed concentration of deuterium was an inherent result of the annealing process described by its application. (A1312 (The feature of the proposed count and new claim 66 that the concentration of deuterium resulting from the disclosed annealing process is “at least about 10^{16} cm⁻³” **is a result of the particular annealing process** described in those applications **and thus is inherently disclosed by each of those applications**”).) Going further, the University explained that inherency is “demonstrated because the effect of the deuterium content as recited in the count (“said concentration of deuterium substantially reducing said degradation associated with said hot carrier stress) is the same as explicitly disclosed in both of these applications.” (A1312–13.) The interference was not initiated, however, because the Examiner determined the University lacked written description support in its application for the claimed concentration. (A1376.)

interface, the '204 patent confirms that the 10-fold lifetime improvement necessarily results from deuterium passivation when compared to the prior art method using hydrogen. (A1064–65, Figs. 2–3; A1068 at 5:60–65 (“[D]ramatic decreases in the degradation of threshold voltage and transconductance are observed when deuterium is used to passivate the devices, as compared to hydrogen passivation These decreases represent practical lifetime improvements by factors of about ten to fifty”); A1069 at 7:47–49 (“[T]ransistors sintered in deuterium typically exhibit lifetimes 10 times longer than those sintered in hydrogen.”). This result is achieved because the post-metal deuterium anneal results in deuterium bonds at the interface. (*See e.g.*, A1937, Declaration of the University’s expert, Dr. Wallace; *see also* A37.) Neither the University nor the '204 patent discloses or claims any other mechanism, condition, or any other factor that is responsible for providing this improved lifetime.

While the '204 patent teaches that both pre- and post-metal passivation in deuterium results in a 10-fold lifetime improvement (as discussed in more detail in Section V.A.2), the University has argued to the Board that post-metal passivation necessarily results in this 10-fold improvement. The University’s argument at the very least confirms the necessary tie between deuterium post-metal passivation and the 10-fold lifetime improvement. The University argued to the Board that even though claim 1 is written in product-by-process form, the recited post-fabrication process passivation in deuterium step should be considered for patentability because it “imply[es]” a ten to fifty-fold difference:

It is clear from the foregoing that, during prosecution, the University undertook great efforts to distinguish the subject invention from the prior art based upon this *ten to fifty-fold difference resulting from post-fabrication passivation using deuterium. In light of the forgoing authority, it is of no moment that this difference is only implied by the claimed post-fabrication process step*, rather than appearing expressly as a claim limitation. Rather, this substantial difference mandates that such claimed post-fabrication passivation step be considered in determining the patentability of the subject claims.

(A1833) (emphasis added).

But that is not all. At oral argument before the Board, the University maintained this argument. For example, in response to Judge Fitzpatrick's question regarding Lisenker's disclosure of a semiconductor device having a ratio of 99:1 deuterium to hydrogen bonds at the interface, the University attempted to draw a contrast to the prior art, emphasizing that

"They're [the claims] directed to how you get to the useful life, *10-fold, 50-fold*, whatever it is *through the use of a post-fabrication passivation step*."

(A2134, 40:9–19.) (emphasis added) The University thus admitted that the claimed 10-fold lifetime improvement is achieved through a post-fabrication passivation step, and nothing more. Consistent with that line of argument, the following exchange occurred:

JUDGE MOORE: . . . Is it your opinion that having the post-fabrication step will result in the improvements that are claimed? In other words, are those two things tied

together or are there ways to have the post-fabrication step but still not achieve the increased resistance that you say -- the increased life that you say is required?

MR. SUMMERFIELD: Well, I think the way I would characterize my answer is that as long as you're practicing all the limitations of the claims. . . . But if the limitations of the claims aren't [*sic*] practiced, including post passivation, then **there is no way to avoid getting the kind of increased life that the claims call for.**

(A2134 at 40:23–A2135 at 41:10.) Yet again, according to the University, a post-fabrication passivation in deuterium is what leads to the claimed increased lifetime.

The University made these arguments in an attempt to overcome Lisenker, which it argued did not disclose a post-fabrication (or “post-metal”) passivation step. The Board disagreed, finding that Lisenker explicitly disclosed such a passivation step, a finding that the University does not appeal. *See* Blue Br. at 8 (“Lisenker teaches the use of pre- and post-metallization annealing...”). In short, the University agreed that post-fabrication passivation in deuterium necessarily results in a 10-fold improvement. Only on appeal does the University contend otherwise.

As discussed in the following section, the Board found that Lisenker explicitly teaches deuterium at the interface. (A1659 at 10:29–35.) Indeed, Lisenker goes further and teaches deuterium retained at the interface at a ratio of 99 to 1 of

deuterium bonds to hydrogen bonds. (A1661 at 12:3–9, 15–17.) The Board also found that Lisenker teaches the use of a pre- and post-metal deuterium passivation step. (A1657 at 8:29–35 (deuterium use throughout the VLSI process)). According to the '204 patent, these requirements result in a 10-fold semiconductor lifetime improvement. Thus, substantial evidence supports the Board's determination that the claimed semiconductor lifetime improvement is necessarily taught by—and an inherent result of—Lisenker.

2. Lisenker discloses the same operative structure and process that the '204 patent discloses.

The '204 patent's disclosure regarding how a 10-fold lifetime improvement is achieved does not extend beyond that of Lisenker's disclosure. Both teach the identical processes and resulting structure. Therefore, to the extent the '204 patent discloses a 10-fold lifetime improvement, so must Lisenker. It is well established that the “the prior art need only meet the inherently disclosed limitation to the extent the patented method does.” *King Pharm., Inc. v. Eon Labs., Inc.*, 616 F.3d 1267, 1275–76 (Fed. Cir. 2010) (“Because the '128 patent discloses no more than taking metaxalone with food, to the extent such a method increases the bioavailability of metaxalone, the identical prior art method does as well.”); *In re Kao*, 639 F.3d 1057, 1070 (Fed. Cir. 2011) (“Substantial evidence supports the Board's finding, based upon the specification, which confirms that the claimed “food effect” is an inherent property of oxymorphone itself, present both in controlled release and immediate release

formulations of that drug.”); *In re Kubin*, 561 F.3d 1351, 1357 (Fed. Cir. 2009) (“[e]ven if no prior art of record explicitly discusses the [limitation], the [patent applicant’s] application itself instructs that [the limitation] is not an additional requirement imposed by the claims on the [claimed invention], but rather a property necessarily present in the [claimed invention].”).¹⁴

Here, just like in the cases cited above, Lisenker discloses all of the ingredients that, according to the ’204 patent, are necessary to achieve a 10-fold semiconductor lifetime improvement. In other words, the respective disclosures of the ’204 patent and Lisenker are at least commensurate in scope. Both disclose the same process (substituting deuterium for hydrogen in the pre- and/or post-metal passivation step), the same structure (deuterium at the interface), and the resulting benefit (that substituting deuterium for hydrogen results in improved semiconductor device resilience manifested in a lifetime improvement). (*Compare* ’204 patent, A1066 at 2:36–39; A1067 at 3:40–48; 4:45–48; A1064–65, Figs. 2–3; A1068 at 5:60–65; A1069 at 7:47–49 *with* Lisenker, A1653 at 4:20–34; A1653–54 at 4:35–5:5; A1654 at 5:6–9;

¹⁴ This Court’s opinion in *In re Glang*, 283 F.3d 1335, 1341–1342 (Fed. Cir. 2002) (on which the University relies) does not instruct otherwise. In *Glang*, this Court found that the prior art did not disclose the benefit (a reduction in the loss of elasticity) because the prior art did not disclose the claimed structure (spaced zones of adhesive) from which the benefit was derived. Because the University does not dispute that Lisenker discloses the claimed structure (*i.e.*, deuterium at the interface), its reliance on *Glang* is simply misplaced.

A1654–55 at 5:36–6:3; A1657 at 8:29–35; A1659 at 10:29–35; A1661 at 12:3–9, 15–17.)

Specifically, both disclose the use of pre- and post-metal deuterium passivation by teaching that the invention involves either (or both). (*Compare*, A1067 at 4:45–48, 4:53–60, 4:61–66 *with* A1657 at 8:29–35 (deuterium use throughout the VLSI process).) This much was confirmed by the University’s expert (A2014 at 130:1–9 (testifying with respect to the parent patent specification, which is substantially identical to the ’204 patent specification),) and not challenged by the University on appeal. *See generally*, Blue Br.¹⁵

Also, both the ’204 patent and Lisenker disclose the same resulting structure—a semiconductor device having deuterium at the interface. For example, Lisenker discloses:

The regions where the deuterated bonds provide the greatest benefit in terms of device performance is at the interface of silicon-silicon dioxide layers. Thus, the semiconductor devices of this invention will have at this interface a ratio of Si-OD plus Si-D bonds to Si-OH plus Si-H bonds that is substantially greater than ratio of naturally occurring deuterium to hydrogen.

(A1659 at 10:29–35; *see also* A1661 at 12:3–9, 15–17 (Lisenker claim 3: “The semiconductor device of claim 2 wherein the ratio of Si-OD plus Si-D bonds to Si-OH plus Si-H bonds is greater than about 99:1.”). There is no dispute that the retained deuterium at the interface is the sole structure responsible for the

¹⁵ The University argued at the Board that Lisenker did not disclose a lifetime improvement.

semiconductor lifetime improvement. Therefore, to the extent the '204 patent concludes that passivation in deuterium results in deuterium at the interface, which in turn results in a 10-fold improvement, those same benefits must necessarily result from Lisenker's disclosure. *In re Kao*, 639 F.3d at 1070 (determining that the Board's inherency decision was supported by substantial evidence where the patentee claimed a maximum concentration of "50% higher" when drug dosages were given on a full stomach, which the patent taught was a property of the drug itself).

3. Lisenker's inherent teachings are not defeated by alternatively-taught embodiments.

And to the extent the University faults Lisenker's teaching of both pre- and post-metal deuterium anneal steps—the prior art's description of alternative embodiments does nothing to alter the inherent teachings of the reference. Lisenker, as the Board determined, clearly discloses a post-metal deuterium anneal step. It matters not one bit whether Lisenker is "agnostic," (Blue Br. at 7) between use of pre- or post-metal passivation steps, or both. *Atlas Powder Co. v. Ireco, Inc.*, 190 F.3d 1342, 1348–49 (Fed. Cir. 1999) (holding that the prior art still inherently taught the "key aspect of Dr. Clay's alleged invention" even though certain embodiments encompassed within the disclosed "broad range" might not perform this "key aspect"). Further, if the University's complaint boils down to Lisenker not explicitly stating "a ten-times lifetime improvement," "an insufficient scientific understanding does not defeat a showing of inherency." *Id.* at 1349. Such an argument should be

disregarded, however, where—as here—the ’204 patent fails to identify any allegedly different structure or process from that which is already described by Lisenker.

4. The Board did not err in referencing the teachings of the ’204 patent specification as to inherency.

It is of no moment that the University faults the Board for relying on the ’204 patent specification for evidence of inherency. (Blue Br. at 12.) The Board is entitled to take the University’s patent at its word, particularly where the ’204 patent discloses no more than the prior art. This Court has affirmed the Board’s inherency determinations based on the exact same reasoning in several circumstances. *In re Kao*, 639 F.3d at 1070 (“Substantial evidence supports the Board’s finding, based upon ***the specification***, which ***confirms that the claimed “food effect” is an inherent property of oxymorphone itself***, present both in controlled release and immediate release formulations of that drug.) (citing *Kubin*, 561 F.3d at 1357 (Fed. Cir. 2009) (stating “[e]ven if no prior art of record explicitly discusses the [limitation], ***[applicant’s] application itself instructs that [the limitation] is*** not an additional requirement imposed by the claims on the [claimed invention], but rather ***a property necessarily present in [the claimed invention]***”)) (emphasis added).

5. Merely measuring and claiming an existing characteristic result of a known process does not make the result patentable.

Another line of cases is instructive. This Court has repeatedly warned that “[n]ewly discovered results of known processes directed to the same purpose are not patentable because such results are inherent.” *Bristol-Myers Squibb Co. v. Ben Venue*

Laboratories, Inc., 246 F.3d 1368, 1376–77 (Fed. Cir. 2001) (internal citations omitted); *see also Abbott Labs. v. Baxter Pharm. Prods.*, 471 F.3d 1363, 1368–69 (Fed. Cir. 2006); *Brassica Prot. Prods. LLC v. Sunrise Farms (In re Cruciferous Sprout Litig.)*, 301 F.3d 1343, 1350–51 & n. 4 (Fed. Cir. 2002).

The situation at hand is similar to *Bristol-Myers* and its progeny inasmuch as the 10-fold lifetime improvement is akin to a newly discovered result. But unlike the prior art in *Bristol-Myers*, Lisenker explicitly recognizes the result—a lifetime improvement. (A1654 at 5:4–5 (“[D]euterium containing devices of the present invention have improved stability, quality, and reliability.”). The only arguably absent teaching is the extent or degree of such improvement. Thus, the 10-fold improvement is at most a newly discovered quantification of a characteristic of the result of the semiconductor fabrication process Lisenker teaches. Merely measuring a characteristic of a prior art process and claiming it does not provide grounds for patentability. *In re Kao*, 639 F.3d at 1072 (affirming holding of obviousness even where “the only claim element not expressly disclosed in the prior art was the previously-unknown, yet inherent, . . . property.”).

In sum, the University is unable to identify a single process step or structure disclosed in the ’204 patent but absent in Lisenker that would account for the claimed 10-fold semiconductor improvement. Thus, Lisenker must inherently disclose this claim element. To the extent the University quibbles with the language of the Board’s opinion as lacking the terms “ten-times” and “inherent,” in the same sentence, such

an argument does not warrant vacatur, particularly where the Board’s conclusions are supported under the standard of review by the evidentiary record. *In re Giuffrida*, 527 Fed. Appx. 981, 986 (Fed. Cir. 2013) (declining “to hold that the Board’s obviousness findings were categorically improper” where the Board’s “‘path may reasonably be discerned,’ even if ‘[i]ts conclusions [we]re cryptic, but ... supported by the record.’”) (citing *In re Huston*, 308 F.3d 1267, 1280–81 (Fed. Cir. 2002) and *In re Applied Materials, Inc.*, 692 F.3d 1289 (Fed. Cir. 2012))).

B. Lisenker’s Inherent Disclosure of the 10-Fold Improvement is Confirmed by the Evidentiary Record

1. The prior art Mikawa reference experimentally confirms a 10-fold semiconductor lifetime improvement as a result of practicing Lisenker’s post-metal deuterium passivation process.

Beyond Lisenker’s explicit disclosure of performing a post-metal anneal in deuterium resulting in retained deuterium at the interface (which according to the ’204 patent necessarily results in a 10-fold lifetime improvement), other record evidence further establishes Lisenker’s 10-fold lifetime improvement disclosure. First, as Micron’s expert, Dr. Reed, testified, another prior art reference, Mikawa, also disclosed tests comparing the effects of substituting deuterium for hydrogen. (A1014–15 at ¶¶ 32–33; *see also* A1969–70 at ¶¶ 10–11; A1670.) Mikawa recognized that such a substitution yielded an order of magnitude reduction in hydrogen bond-breaking events, which is consistent with the same 10-fold lifetime improvement

described by the '204 patent. *Id.*¹⁶ Thus, prior art teachings experimentally confirm that Lisenker inherently discloses the 10-fold lifetime improvement.

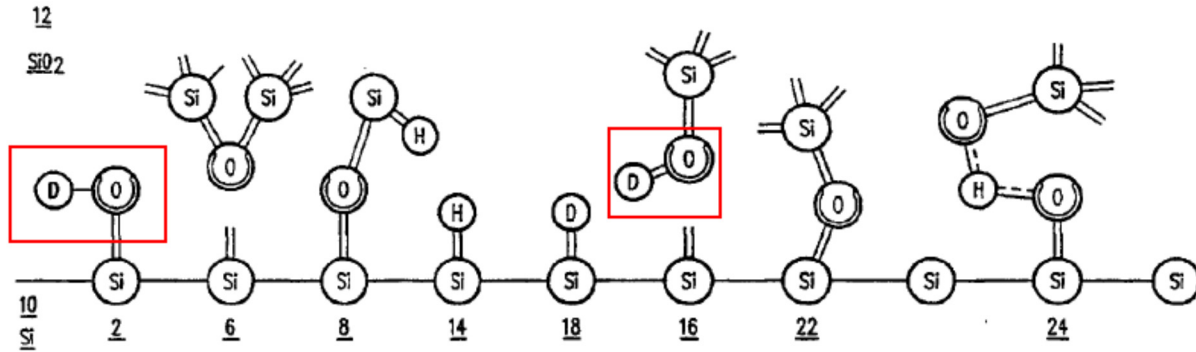
2. Evidence before the Board confirmed Lisenker's teaching of a 10-fold semiconductor lifetime improvement.

Second, Dr. Reed testified that Lisenker discloses representative values of molecular bond energies of hydrogen- and deuterium-containing bonds and that from these values, one of skill in the art could estimate relative rates of bond-breaking reactions. The relative rate, "k," of a chemical reaction can be estimated through use of the Arrhenius equation and correlated to the lifetime improvement of the device in the context of deuterium substitution for hydrogen. (A1010 at ¶ 22.) Given the molecular bond energy values disclosed by Lisenker, Micron's expert derived the corresponding difference in rates at room temperature by applying the Arrhenius equation and determined the difference in rates of bond breaking between the Si-H and Si-D bonds is approximately 3.9 times longer for Si-D bonds and the difference between the O-H and O-D bonds is approximately 35 times longer for O-D bonds.¹⁷

¹⁶ Dr. Reed also explained that the "bond breaking" referred to by Mikawa is the mechanism that causes device degradation and, therefore, a reduction in bond breaking events directly corresponds to a lifetime improvement. (A1004–06 at ¶¶ 12–14.)

¹⁷ The University's brief and Statement of Facts on this point tell only half the story. While it is true that the low end of the bond-breaking improvement estimate was 3.9 times, the University left out the full scope of Micron's expert's opinions. Indeed, Micron's expert testified that the upper end of the of the bond-breaking improvement estimate was 35 times—well beyond the 10-times lifetime improvement upon which the University relies.

(A1009–13 at ¶¶ 20–29.) As Lisenker shows at Figure 1, the Si/SiO₂ interface includes both Si-D and O-D bonds, when deuterium replaces hydrogen as the annealing gas.¹⁸ (A1648.)



(A1648, Figure 1 of Lisenker, with the O-D bonds annotated.)

Micron’s expert concluded that these results for devices made by a post-metal annealed in deuterium—correlated to an estimated lifetime improvement of *at least 3.9 times and up to 35 times longer* than post-metal annealed in hydrogen—were consistent with the ’204 patent disclosure of a 10-times lifetime improvement.

(A1012–13 at ¶ 29.) Thus, the teachings of Mikawa and Lisenker further establish that Lisenker inherently discloses a 10-fold lifetime improvement. For this additional

¹⁸ During argument before the Board, the University falsely argued that OD bonds are not implicated by Figure 1 of Lisenker. (A2125 (George Summerfield: “There’s nothing in Figure 1 from Lisenker that implicates forming bonds with oxygen at all. So why Dr. Reed felt compelled to look at the relative strengths between Si-O -- I’m sorry, SOH and OD bonds is beyond us, effectively.”).) Setting aside that this is attorney argument, unsupported by any testimony of even the University’s expert, the University’s argument is clearly rebutted by the existence of O-D bonds, as noted above in annotated Figure 1 and as claimed at Lisenker’s claim 1. (A1648; A1661 at 12:3-9 (“... *the interface having Si-OD and Si-D bonds*, wherein the *ratio of Si-OD plus Si-D bonds* to Si-OH plus Si-H bonds is substantially greater than ratio of naturally occurring deuterium to hydrogen.”).)

reason, substantial evidence supports the Board’s finding that Lisenker inherently discloses a 10-fold lifetime improvement.

VI. Even if the 10-Fold Lifetime Improvement is not Inherent, the Board Relied on Substantial Evidence to Determine That it is Obvious

A. Lisenker renders claim 13 obvious.

In its brief, the University does not identify a device structure or method step that is not explicitly disclosed in Lisenker. Moreover, the University does not dispute that Lisenker explicitly discloses a device lifetime improvement. *See generally*, Blue Br. The University’s sole basis for patentability is that claim 13 of the ’204 patent recites an improvement to a greater degree than that explicitly taught in the prior art. In making its argument, however, the University conflates inherency (a form of anticipation) and obviousness. This Court has made clear that arguments rebutting anticipation are not sufficient to rebut obviousness. *See In re Baxter Travenol Labs.*, 952 F.2d 388, 391-92 (Fed. Cir. 1991) (dismissing patentee’s argument regarding nonobviousness, which was “essentially the same argument advanced to rebut the anticipation rejection” explaining that “[i]t is not the function of this court to examine the claims in greater detail than argued by an appellant, looking for nonobvious distinctions over the prior art.”) In other words, just because a claim element is not inherent does not foreclose a determination that it is nonetheless obvious. *See Rexnord Indus., LLC v. Kappos*, 705 F.3d 1347, 1345–55 (Fed. Cir. 2013) (agreeing with the

Board that a claim element was not inherent in the asserted prior art, but concluding the Board erred in determining that the same element would not have been obvious).

Tellingly, the University does not argue why it would not have been apparent to a person of skill in the art to obtain an improved semiconductor lifetime (*i.e.*, the 10-fold improvement). Indeed, achieving a lifetime improvement (*i.e.*, making high quality, stable devices) is the purpose of the prior art that was before the Board. *See e.g.*, A1654 at 5:4–5 (“Therefore, the deuterium containing devices of the present invention have improved stability, quality, and reliability.”). In view of the teachings of the prior art such as Lisenker, it is not surprising that the University is unable to articulate why such an aspirational claim limitation is nonobvious.

As set forth in Section V.A.2, the 10-fold semiconductor lifetime improvement is at most a newly discovered quantification of a known characteristic. Mere quantification cannot transform an obvious claim into one that is nonobvious. *Santarus, Inc. v. Par Pharm., Inc.*, 694 F.3d 1344, 1354 (Fed. Cir. 2012) (“an obvious formulation cannot become nonobvious simply by administering it to a patient and claiming the resulting serum concentrations.”); *Kao*, 639 F.3d at 1070 (“[The prior art’s] express teachings render the claimed ... formulation obvious, and the claimed [blood concentration] adds nothing of patentable consequence.”).

Furthermore, even if the 10-fold lifetime improvement were not inherent in Lisenker (which it is), such a deficiency would not alter this conclusion. For example, even if it were agreed that Lisenker only teaches a 5-fold improvement, it is well-

established that a change in only degree is a change that will not sustain a patent.

Application of Blondiau, 181 F.2d 223, 225 (Cust. & Pat. App. 1950) (“As said so long ago by the Supreme Court in *Smith v. Nichols*, 21 Wall. 112, 88 U.S. 112, 119, 22 L.Ed. 566, ‘a mere carrying forward or new or more extended application of the original thought, a change only in form, proportions, or degree, the substitution of equivalents, doing substantially the same thing in the same way by substantially the same means with better results, is not such invention as will sustain a patent.’”).

Whether the claimed improvement were 10-fold or 100-fold, the University cannot point to an optimum concentration of deuterium retained at the interface or any other characteristic of the structure or process disclosed by the ’204 patent that would contribute to a lifetime improvement beyond that disclosed by Lisenker. The ’204 patent simply fails to disclose such detail. Even if the University could identify a relevant disclosure, the measured 10-fold improvement would be the product of routine experimentation and not the product of invention. *Id.* at 225 (“Achievements which result from trial and error experimentation are the product of a routineer and not an inventor.”) (citing *Rembert et al. v. Coe*, 136 F.2d 793 (D.C. Cir. 1943)); *Application of Aller*, 220 F.2d 454, 458 (Cust. & Pat. App. 1955) (“No invention is involved in discovering optimum ranges of a process by routine experimentation.”).

B. Lisenker in view of Gise (or both Gise and Ito) renders claim 13 obvious.

The same holds true for the other grounds the Board relied upon to find claim 13 obvious. For example, were there any question as to Lisenker's disclosure of post-metal passivation (which there is not), the Board found this step would have been obvious over Lisenker alone or in view of Gise. The University does not dispute the Board's findings. (A32–33; A43 (citing A1717–18, Gise at 130–31); *see generally* Blue Br. (containing no challenge to Gise's teachings).)

Though the University does not challenge Gise's teachings, it tries to impugn the Board's opinion, arguing that “nowhere does the Board explain the motivation to combine these references.” (Blue Br. at 13.) This argument is a false characterization of the record. In making its finding as to Lisenker in view of Gise (and further in view of Ito), the Board specifically relied on the University's expert's testimony that “post metal hydrogen annealing had been in widespread use in the semiconductor industry for many years,” (A38–39,) and credited the testimony of Micron's expert Dr. Reed “that ‘it would have been apparent to perform Lisenker's annealing process after the metallization steps have been performed’ in light of Gise's teaching.” (A43 (citing A1017 at ¶ 36).) As explained by Dr. Reed, Gise teaches that post-metal annealing “‘is designed to optimize and stabilize device characteristics’ ... and Gise clearly establishes that the post-metallization anneal in hydrogen is a standard step in integrated circuit fabrication.” (A1017 at ¶ 36 (quoting Gise); *see also* A1717–18.)

Thus, the Board relied on substantial evidence in finding that one of ordinary skill in the art would have been motivated to include a post-metal anneal step in Lisenker to the extent Lisenker does not already disclose such a process.¹⁹

Given the University's concession that "Lisenker teaches the use of pre- and post-metallization annealing" (Blue Br. at 8) and its inability to dispute the motivation found in Gise, the University's argument that "there would have been no motivation for one of ordinary skill in the art reading Lisenker to have sought out other references teaching post-metallization annealing specifically" (*id.*) is without merit.

C. Deal in view of Lisenker and Ito renders claim 13 obvious.

1. The University does not challenge the Board's factual findings.

The University does not challenge the Board's reasoning in finding claim 13 obvious over Deal in view of Lisenker and Ito. Indeed, a simple word search indicates that nowhere in its brief does the University even mention the Deal or Ito references. As such, any challenge to this combination is waived and the Board's judgment rendering claim 13 invalid should be affirmed.

While the University *generally* challenges the Board's opinion stating that "nowhere does the Board explain the motivation to combine these references," (Blue Br. at 13), as mentioned above, that is a false characterization of the record. The Board extensively analyzed the reasons to combine Lisenker and Ito's teachings with

¹⁹ The Board also explained the motivation to combine Ito for the combination of Lisenker in view of Gise and Ito. (A44–45.) The University does not appeal any issue germane to Ito's teachings.

Deal. Here, the Board found that Deal teaches the subject matter of the claims except for the retention of deuterium at the interface. (A46.) Specifically, the Board found that Deal discloses post-metal annealing in hydrogen. (A47.) The Board also found, as a factual matter, that “Lisenker suggests to the person of ordinary skill in the art to modify Deal’s post-metal anneal by substituting deuterium for hydrogen.” *Id.* In reaching this conclusion, the Board relied on Micron’s expert’s testimony that “Lisenker teaches the substitution of deuterium for hydrogen and states that such a substitution results in ‘bonds that are less likely to break when exposed to electrical stresses,’ which improves device ‘stability, quality, and reliability.’” (A46 (quoting A1024 at ¶ 49 (quoting Lisenker, A1654 at 5:2–5))). Similarly, the Board credited Dr. Reed’s testimony that it would have been apparent to substitute Ito’s thin insulating layer into the teachings of Lisenker. (A47.) The Board thoroughly explained the motivation to combine Deal, Lisenker, and Ito. Its judgment rendering claim 13 invalid in view of this combination should be affirmed.

2. The University’s challenge to Lisenker’s teaching is irrelevant to how Lisenker is used in the combination of Deal in view of Lisenker and Ito.

The University’s argument that Lisenker “fails to distinguish between pre- and post-metallization annealing in achieving the reported superior results,” (Blue Br. at 12,) is misplaced in the context of a combination of Deal in view of Lisenker and Ito.

As a challenge to this particular combination, the University's argument is frivolous²⁰ because it was Deal—not Lisenker—which was relied upon in the combination of Deal in view of Lisenker and Ito for a post-metal anneal teaching. (A47.) Deal's teachings are undisputed. *Id.* Lisenker, as the Board noted, was only relied upon by Micron (in the combination of Deal in view of Lisenker) for its suggestion “to modify Deal's post-metal anneal by substituting deuterium for hydrogen.” *Id.* Based on the evidence and arguments before it, the Board properly concluded that claim 13 “would have been obvious over Deal, Lisenker, and Ito.” *Id.*

3. The University's current argument against the combinability of Deal in view of Lisenker and Ito is waived.

Though the University fails to specifically challenge the combination of Deal in view of Lisenker and Ito, it does assert that Lisenker supposedly “fails to distinguish between pre- and post-metallization annealing in achieving the reported superior results.” (Blue Br. at 12.) This argument is waived, because the University did not present it below. *In re Watts*, 354 F.3d 1362, 1367–68 (Fed. Cir. 2004) (declining to “consider the appellant's new argument regarding the scope of the” prior art “[b]ecause the appellant failed to argue his current interpretation of the prior art below” and “[the Court] do[es] not have the benefit of the Board's informed

²⁰ The University cannot possibly prevail over the combination of Deal in view of Lisenker and Ito where, as here, the only argument it makes against the combination is as to a teaching of Lisenker for which the reference is not relied upon in this combination.

judgment on this issue for our review.”) (citing *In re Berger*, 279 F.3d 975, 984 (Fed. Cir. 2002) and *In re Schreiber*, 128 F.3d 1473, 1479 (Fed. Cir. 1997)).

Before the Board, the University argued against the combination of Lisenker and Hwang with Deal, asserting its same prior arguments—essentially that Lisenker is limited to pre-metal annealing and, thus, results in no increase in deuterium at the interface. (See Final Written Decision at A47; see also University Patent Owner Response A1830.) Now, the University argues **not** that Lisenker is limited to pre-metal annealing, **but** that Lisenker fails to distinguish between pre- and post-metal annealing. (Blue Br. at 13.) This new argument was not made below with respect to the combination of Deal in view of Lisenker and Ito. It is thus waived. The Board’s judgment that claim 13 is obvious over Deal in view of Lisenker and Ito should thus be affirmed.

D. A Change In Degree Is Not A Patentable Distinction

All of the aforementioned combinations unquestionably disclose a post-metal anneal in deuterium resulting in deuterium at the interface and (according to the ’204 patent and the University’s own arguments) a 10-fold lifetime improvement. But even if the 10-fold improvement does not necessarily follow from the disclosures of the prior art, the question then is whether such an improvement would have been obvious. As each of the prior art references in the aforementioned combinations sought to improve the quality and reliability of the semiconductor devices, substantial evidence supports a finding that the 10-fold improvement would have been obvious

to one of skill in the art. As set forth above, a change in only degree is a change that will not sustain a patent. *Blondiau*, 181 F.2d at 225. Prior art such as Mikawa, moreover, indicates to a person of ordinary skill in the art that substitution of deuterium for hydrogen would lead to a ten-time reduction in bond-breaking events, correlated to a ten-times semiconductor lifetime performance. (A1014 at ¶¶ 32–33 (internal citations omitted) (emphasis added); *see also* A1969 at ¶ 10; A1670 – Mikawa; A1947, Micron Reply to University Patent Owner Response (discussing Mikawa’s teachings); A2113 at 19:4–21, Micron’s Argument to the Board (same).) Thus, the Board’s obviousness findings with respect to claim 13 are supported by substantial evidence.

VII. The Board Did Not Err Because the 10-Fold Lifetime Improvement Must not be Considered for Purposes of Patentability

A. Product-by-Process Treatment of Claim 13 Removes the 10-Fold Lifetime Improvement From the Patentability Determination

“Product-by-process claims . . . enable an applicant to claim an otherwise patentable product that resists definition by other than the process by which it is made.” *In re Thorpe*, 777 F.2d 695, 697 (Fed. Cir. 1985). “In determining validity of a product-by-process claim, the focus is on the product and not the process of making it.” *Amgen Inc. v. F. Hoffman–La Roche Ltd.*, 580 F.3d 1340, 1369 (Fed. Cir. 2009).

Thus, “[i]f the product in a product-by-process claim is the same as or obvious from a product of the prior art, the claim is unpatentable even though the prior product was made by a different process.” *Thorpe*, 777 F.2d at 697; *see also SmithKline Beecham Corp.*

v. Apotex Corp., 439 F.3d 1312, 1317 (Fed. Cir. 2006) (“It has long been established that one cannot avoid anticipation by an earlier product disclosure by claiming ... the product as produced by a particular process.”); *Thorpe*, 777 F.2d at 697 (“If the product in a product-by-process claim is the same as or obvious from a product of the prior art, the claim is unpatentable even though the prior product was made by a different process.”).

Claim 13 of the '204 patent recites a semiconductor device having deuterium at the interface between a semiconductive silicon layer and a gate insulating layer manufactured according to a specific process (*i.e.*, post-fabrication passivation of said interface in a heated, deuterium gas enriched atmosphere . . .). Thus, the Board correctly determined that claim 13 must be given product-by-process treatment and, therefore, requires deuterium at the interface, “but not as a result of any particular process.” (A29; *see also* A27–29.) In short, the Board found that the process of claim 13 (in bold below) must not be considered for purposes of patentability.

A semiconductor device comprising a field effect transistor having an interface between a semiconductive silicon layer and a gate insulating layer, structurally characterized by the gate insulating layer having a thickness not exceeding about 55 Angstroms and by the presence of deuterium at said interface ***resulting from post-fabrication passivation of said interface in a heated, deuterium gas-enriched atmosphere at a temperature above about 200° C. so as to increase the resilience of the field effect transistor to hot electron effects, said post-fabrication passivation being conducted sufficiently to provide to said transistor a practical lifetime at least about ten times that provided by a corresponding passivation with hydrogen, wherein practical lifetime is taken as 20% transconductance degradation as a result of electrical stress.***

(A108–A109 at 8:64–9:11 (emphasis added).)

This finding was made explicit in the Board’s Notice of Institution. (A1782–84.) In construing the claim language in bold above, the Board concluded that “[w]e construe each of the above-quoted limitations of claims 6, 10, 13, and 14 to require deuterium at the interface. A reference teaching deuterium at the interface would meet this requirement even if formed by a process different than that which is claimed.”²¹ (A1784; *accord* A29.)

The 10-fold lifetime improvement limitation of claim 13 (underlined above) is recited as ***part of the process*** and does not connote any structure not already recited in the claim itself (*i.e.*, deuterium at the interface). Indeed, it is undisputed that the deuterium at the interface is the sole structure responsible for the lifetime improvement. (A1832, University’s Patent Owner Response (Below, the University argued that “[the ’204 patent] claim language requires improved resistance to hot carrier effects ***resulting from*** retention of deuterium at the silicon/insulator interface ***resulting from*** post-fabrication passivation using deuterium.”) (emphasis in original).) Thus, the University cannot rely on this limitation to distinguish prior art such as Lisenker, which indisputably discloses deuterium at the interface. *Amgen*, 580 F.3d at

²¹ The University states on multiple occasions that the Board “said nothing” about the 10-fold increase in semiconductor lifetime performance of claim 13. (Blue Br. at 6, 8, and 10) That is both misleading and wrong. The Board clearly addressed claim 13, in particular—its construction—and determined that the described process, which includes the 10-fold lifetime element, could not be considered in the patentability analysis.

1369; *see also* (Lisenker at A1659 at 10:29–35; A1661 at 12:3–9, 15–17; A1648 at Fig. 1.).

B. The Law Does Not Support the University’s Arguments, Which Were Properly Rejected by the Board

The University may argue that the process of claim 13 imparts additional structure beyond that which is explicitly claimed, per this Court’s opinion in *Greenliant Sys., Inc. v. Xicor LLC*, 692 F.3d 1261, 1268 (Fed. Cir. 2012). *Greenliant* states “if the process by which a product is made imparts ‘structural and functional differences’ distinguishing the claimed product from the prior art, then those differences ‘are relevant as evidence of no anticipation’ *although they ‘are not explicitly part of the claim.’*” *Greenliant*, 692 F.3d 1261 at 1268 (emphasis added). Claim 13, however, explicitly recites the structure (*i.e.*, deuterium at the interface) that is imparted by the process. Thus, *Greenliant* is inapposite here.²²

²² In its Patent Owner’s Response, the University unsuccessfully relied on *Greenliant* with regard to another product-by-process claim, namely, claim 1. In so doing, the University argued that the recited process (“post-fabrication passivation using deuterium...”) of claim 1 imparts structure other than that which is explicitly claimed. The Board properly rejected the University’s argument because i) the recited process did not impart structure beyond that which was already claimed and the experimental results relied upon by the University in its application failed to link lifetime extension to anything other than general deuterium passivation, as opposed to post-fabrication passivation. (A28–29.) Notably and discussed in further detail in Section V.A.5, the University argued that the “ten to fifty-fold difference” results from post-fabrication passivation such that “this substantial difference mandates that such claimed post-fabrication passivation step be considered in determining the patentability of the subject claims.” (A1833.) In other words, the University argued that the disclosure of post-fabrication passivation in deuterium necessarily results in a 10-fold lifetime improvement. The University admits that Lisenker discloses post-

C. The University Failed to Raise Below or Argue on Appeal the Board’s Product-by-Process Treatment of Claim 13 and Has, Therefore, Waived This Issue.

The University has not challenged the Board’s finding that claim 13 should be given product-by-process treatment on appeal. Nor could it. The University waived any such challenge at oral argument before the Board:

First of all, we agree the claims of the ’204 and ’387 patents are all product-by-process claims, as shown in Micron’s summary slide number 16. . . . We’re not asking the court to reverse itself on whether the claims of the two patents are actually product-by-process claims or how they should be resolved as far as construction is concerned.

(A2121 at 27:2–9.) Nor has the University challenged the Board’s finding that claim 13 requires deuterium at the interface, “but not as a result of any particular process.” (A29.); *see generally*, Blue Br. The University’s failure to challenge the Board’s finding below, or on appeal, amounts to a waiver of the issue. *In re Baxter Int’l Inc.*, 678 F.3d 1357, 1362 (Fed. Cir. 2012) (“ . . . [W]e generally do not consider arguments that the applicant failed to present to the Board.”) (citing *Watts*, 354 F.3d at 1367–68 (Fed. Cir. 2004)); *see also Engel Indus., Inc. v. Lockformer Co.*, 166 F.3d 1379, 1382–83 (Fed. Cir. 1999) (noting that the court “is entitled to assume that an appellant has raised all issues it deems important” and that “[a]n issue that falls within the scope of the judgment appealed from but is not raised by the appellant in its opening brief on appeal is necessarily waived”); *see also Novosteel SA v. U.S.*, 284 F.3d 1261 at 1274 (Fed.

fabrication passivation (*see* Blue Br. at 8) and, by its own logic, tacitly admits that Lisenker also discloses the attendant lifetime improvement.

Cir. 2002) (“Raising the issue for the first time in a reply brief does not suffice; reply briefs reply to arguments made in the response brief--they do not provide the moving party with a new opportunity to present yet another issue for the court’s consideration.”); *Abbott Labs. v. Syntron Bioresearch, Inc.*, 334 F.3d 1343, 1355 (Fed. Cir. 2003) (“Abbott has waived the doctrine of equivalents argument by failing to raise it in its opening brief.”).

Because the Board properly found that the 10-fold lifetime improvement limitation must not be considered for purposes of patentability and the University failed to challenge this finding, whether a 10-fold lifetime improvement is taught by or obvious in view of the prior art is of no moment to the patentability of claim 13. Thus, if the Court determines this issue was waived, it need not reach a decision on inherency and obviousness.

CONCLUSION

For the reasons above, the Court should affirm the judgment of the Board, as it is supported by substantial evidence.

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Respectfully submitted,

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CERTIFICATE OF SERVICE AND FILING

I certify that I electronically filed the foregoing document using the Court's CM/ECF filing system. Counsel was served via CM/ECF on October 14, 2014.

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CERTIFICATE OF COMPLIANCE

The undersigned attorney certifies that the opposition brief for Appellee Micron Technology, Inc. complies with the type-volume limitation set forth in Fed. R. App. P. 28.1(e)(2)(B). The relevant portions of the brief, including all footnotes, contain 11,823 words as determined by Microsoft Word.

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